# Measuring Urban Microclimates and Vertical Temperature Profiles in Portland, Oregon for Analyzing Energy Budgets and Air Pollution Sources

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## Background

Major goals of this study included 1) making new measurements and analyses of the vertical temperature profile (VTP) in a topographically complex urban area for identification of temperature inversion patterns and applications to building energy conservation, and 2) assessment of local air pollution sources. Results show frequent, strong, low-level temperature inversions following consistent diurnal patterns, with important implications for local air pollution concentrations and circulation. Other results demonstrate some avoidable cool-season heating losses from the buildings within the study area, especially through building rooftops. Methods centered on installing a dense network of remote automated weather stations in contrasting microclimates spanning a range of 70 m in the vertical from the lowest to highest station altitude within a horizontal area of only 0.25 km$^2$. Measurements included air temperatures and humidities at multiple heights per station, wind speed, wind direction, wind gusts, incoming solar radiation in several spectral ranges, precipitation, air pressure, and boundary layer fluxes.

## Study Area

The study site in Portland, Oregon features complex natural topography including a major river and steep adjacent bluff, tall buildings, heavy industrial air pollution sources, a major shipyard, significant variations in vegetation types and coverage, and a residential neighborhood where complaints about poor air quality are common.

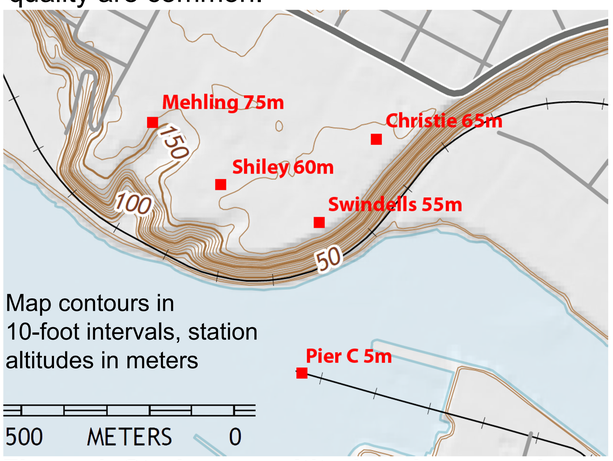
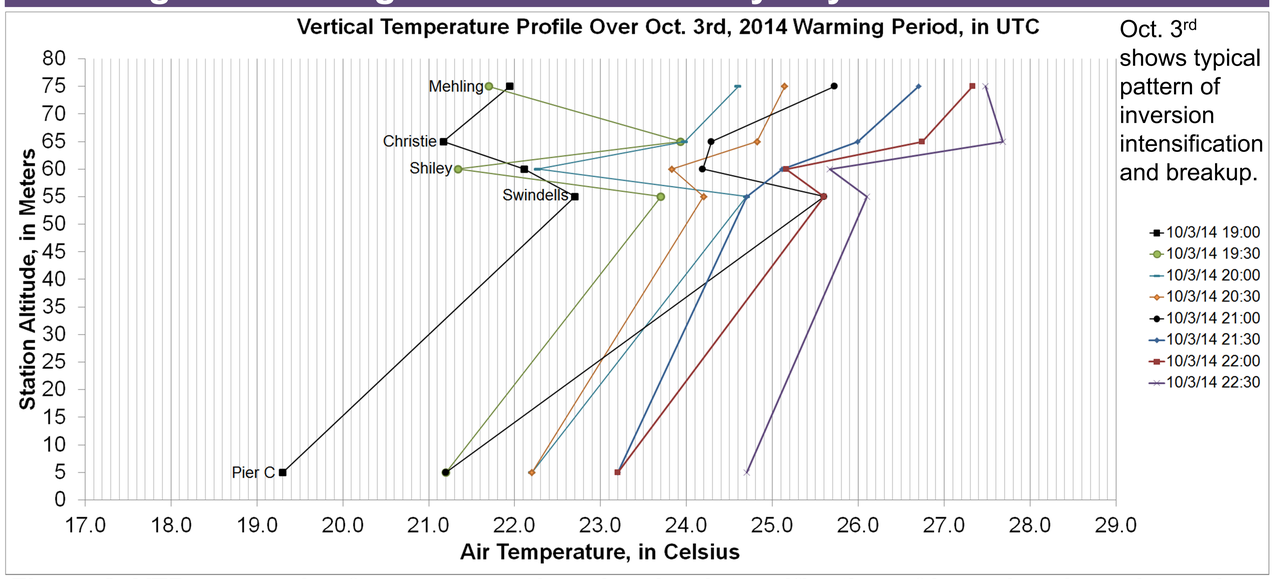



**Figure 1. Study area: altitudes above sea level**

## Warming and Cooling Periods in Boundary-Layer VTP




Oct. 3rd shows typical pattern of inversion intensification and breakup.

**Figure 2. VTP over early afternoon warming showing intensification of boundary-layer inversion.**

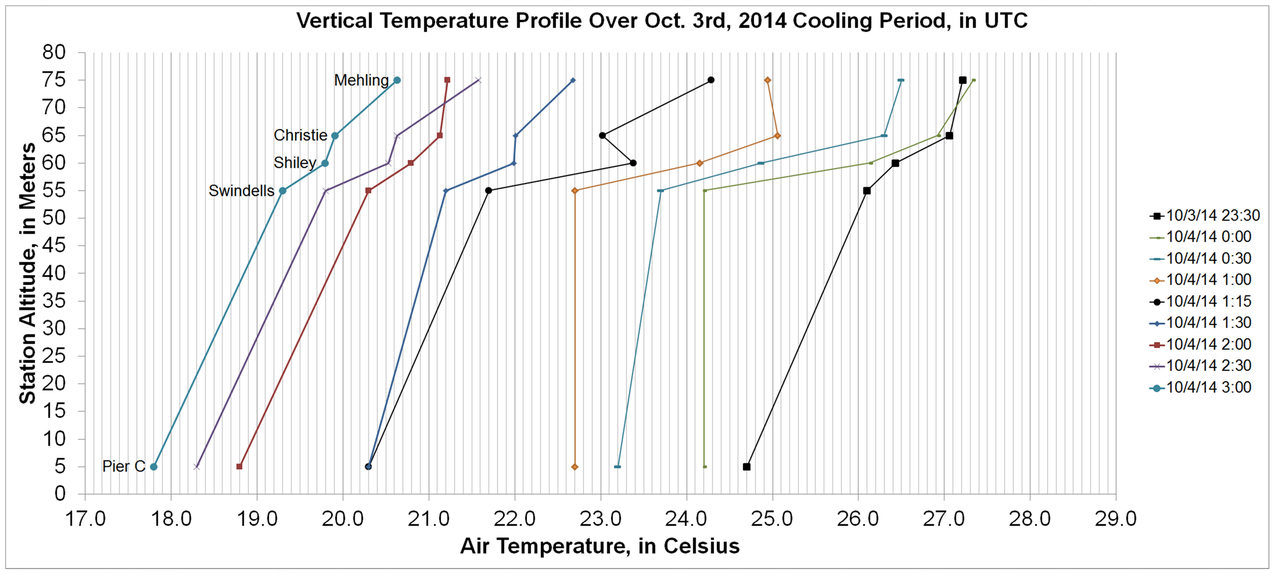



**Figure 3. VTP over after daytime max temperature showing breakup of boundary-layer inversion.**

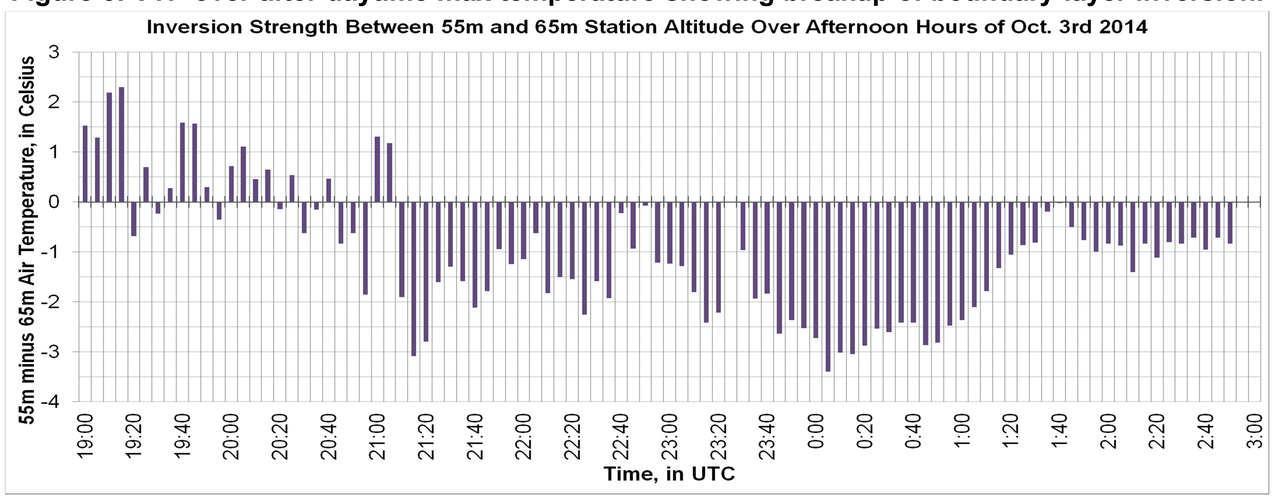



**Figure 4. Inversion intensity between "Swindells" (55m) and "Christie" (65m) station altitudes.**

## Month-Long Observed Pattern

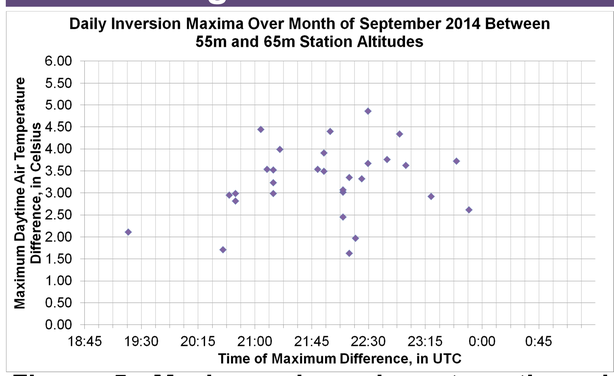



**Figure 5. Maximum inversion strength and daily time of occurrence for month of Sept.**

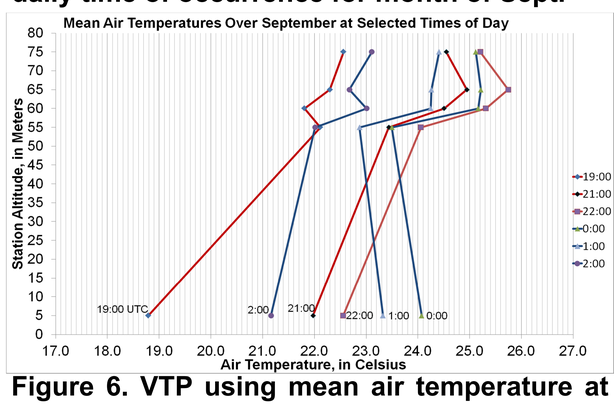



**Figure 6. VTP using mean air temperature at selected times of day over month of Sept.**

## Conclusions

Results indicate a consistent diurnal pattern of boundary-layer temperature inversion intensification and breakup. An inversion appears most often between the 55m "Swindells" station and the 65m "Christie" station. Over the month of September, 2014 daily inversion maxima occurred between 19:20 and 23:50 UTC with a mean of 21:54 UTC. Maximum inversion strength between 55m and 65m ranged from 1.63 to 4.86°C, with a mean of 3.27°C. Inversion growth is a product of increased surface and ambient air heating during the morning through early afternoon period and greater ambient air cooling at points higher in altitude and further from mitigating factors (vegetation coverage, Willamette river) over the late-afternoon and nighttime cooling period. The inversion altitude prevents the dispersion of local air pollutants on "The Bluff" – a residential neighborhood with a high population density. Our study demonstrates the need for micro-level analysis of the VTP in assessing patterns of pollution trapping, low-level temperature inversions.